

Preface

This book has its genesis in the 2007 Materials Research Society (MRS) Fall Meeting where we organized the symposium “Nanoscale Magnetic Materials and Applications”. This symposium, with more than 200 submissions of presentations and 30 invited talks, was one of the most successful meetings in magnetic materials research in recent years. Ms. Elaine Tham from Springer suggested us to edit a book based on the topics presented in this symposium. We invited a number of presenters in the symposium to be the authors of this book which shares the title of the symposium. Moreover, we have extended the scope of the book to other topics as well that were not covered in the symposium.

Magnetic materials have a long history. People have been using compasses for thousands of years. However, new magnetic materials and applications are emerging and are proving indispensable in our daily lives and modern industries. One example is that there are already over a billion giant magnetoresistance sensors produced for information technology and other related applications. Hard and soft magnetic materials are key for efficient energy conversion, especially for converting electric energy to mechanical energy so that they are important to meet the challenges of the depletion of fossil fuels, climate change, and global warming.

Nanotechnology is one of the most important developments in science and technology in our generation, and it has brought revolutionary progress in materials processing and characterization. Current magnetic nanotechnologies have their roots in the development of bulk materials, such as permanent magnets where the functionality is derived from a complex nanoscale multi-phase morphology. Nanotechnology has offered a coupling of synthesis, theory, and characterization of materials at the nanoscale that enables materials design to evolve beyond earlier Edisonian approaches. By its very nature, magnetic materials are a class of nanoscale materials. Although early researchers did not explicitly work on the nanoscale, theoretical research revealed some time ago that nanoscale correlations exist in magnetic materials and control their properties. Several important characteristic dimensions in magnetism are in the nanoscale range such as the magnetic domain wall thickness and the “exchange length” in hard magnetic phases. This highlights why the research and development of new nanoscale magnetic materials are important and will lead to enhanced performance and new functionality. Some recent examples highlighted in this book include patterned magnetic recording

media and exchange-coupled nanocomposite magnets, where intense worldwide efforts are underway to significantly improve the areal density of data storage and the energy product of permanent magnets, respectively.

This book covers many of the exciting areas in nanoscale magnetic materials and applications. Readers will find topics in the book including theoretical work on novel magnetic structures, characterization of magnetic structures, single-phase materials and nanocomposite magnets, spintronic materials, domain structure and domain wall motion, magnetic nanoparticles and patterned magnetic recording media, magnetocaloric effect, and shape memory effect. The book also covers the most important emerging applications of advanced materials. The applications include new devices based on domain wall motion driven by current or fields, new magnetic sensors based on giant magnetoresistance and tunneling magnetoresistance, soft and hard magnetic materials for specific applications, thin-film applications in micro-electro-mechanical systems, and nanoparticle applications in biomedicine. We hope that this new book provides a comprehensive view of recent progress in all the related fields.

While attempting to present the most exciting developments in materials research and device applications, discussions in depth about the novel phenomena and emerging new materials are also presented in the book, such as the controllable exchange bias and inter-phase exchange interactions. Though more work is needed to understand the issues, we hope that this book gives a good introduction to future advancement.

We thank Prof. Peter Grünberg, the 2007 Nobel Laureate in Physics, for giving his insightful and visionary foreword to this book. We thank Ms. Elaine Tham and Ms. Lauren Danahy from Springer who initiated this book and did a great deal of work to bring it to completion. Mrs. Grace Liu has worked hard in collecting all the manuscripts, figures, and related paperwork. Finally, we thank all of our authors who contributed their very informative and in-depth chapters which made this new book a reality.

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